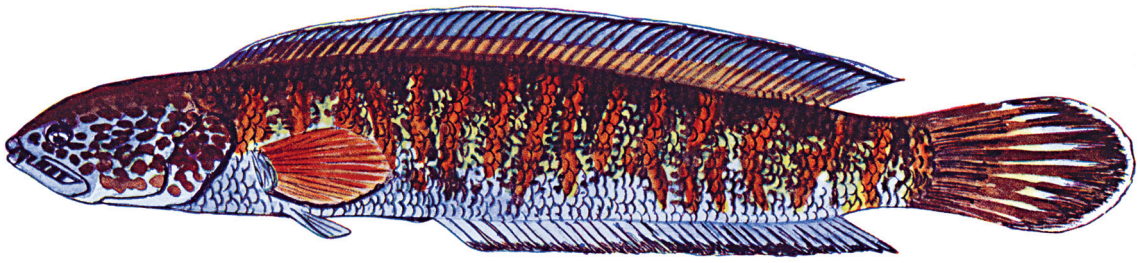
SPECIES ACCOUNTS

Channa amphibeus (McClelland, 1845)
Chel Snakehead



After Shaw and Shebbeare, 1938

Original description: *Ophiocephalus amphibeus* McClelland, 1845:274-282. Description of four species of fishes at the foot of the Boutan Mountains. Journal of Natural History, Calcutta, 5(18):274-282. Type locality: vicinity of tributaries of the Teesta (=Tista) River below the Boutan (Bhutan) mountains. Neotype: ZSI F 11435.

Synonyms: *Ophiocephalus amphibius* [sic], Day, 1877:365.

Ophiocephalus amphibius [sic], Shaw and Shebbeare, 1938:119-121 (vicinity of Chel River, northern Bengal).

Channa amphibia [sic], Jayaram, 1981.

Channa amphibius [sic], Talwar and Jhingran, 1992.

Channa amphibious [sic], Eschmeyer, 1998:92.

Common names: In northern Bengal: bora cheng (Mechi), borna (Rabha) (Shaw and Shebbeare, 1938). We suggest **Chel snakehead**.

Native range: Endemic to Chel River basin, Brahmaputra River drainage, northeastern India and Bhutan (Musikasinthorn, 2000).

Introduced range: No introductions known.

Size: To about 25 cm.

Habitat preference: No specific information, but distribution indicates preference for rivers, streams, ponds, perhaps swamps in the Chel River basin, Brahmaputra drainage, of northeastern India and Bhutan (Musikasinthorn, 2000). Shaw and Shebbeare (1938) reported that during rainy periods, young are found "in flooded paddy-fields enclosed by forest; large fish can be found in pools of dried streams in forests."

Temperature range: No specific information. Habitat preference and range indicate a warm temperate to subtropical species.

Reproductive habits: No specific information, but probably builds a cylindrical nest in vegetation and produces pelagic eggs.

Feeding habits: No specific information, but likely a carnivorous predator as an adult.

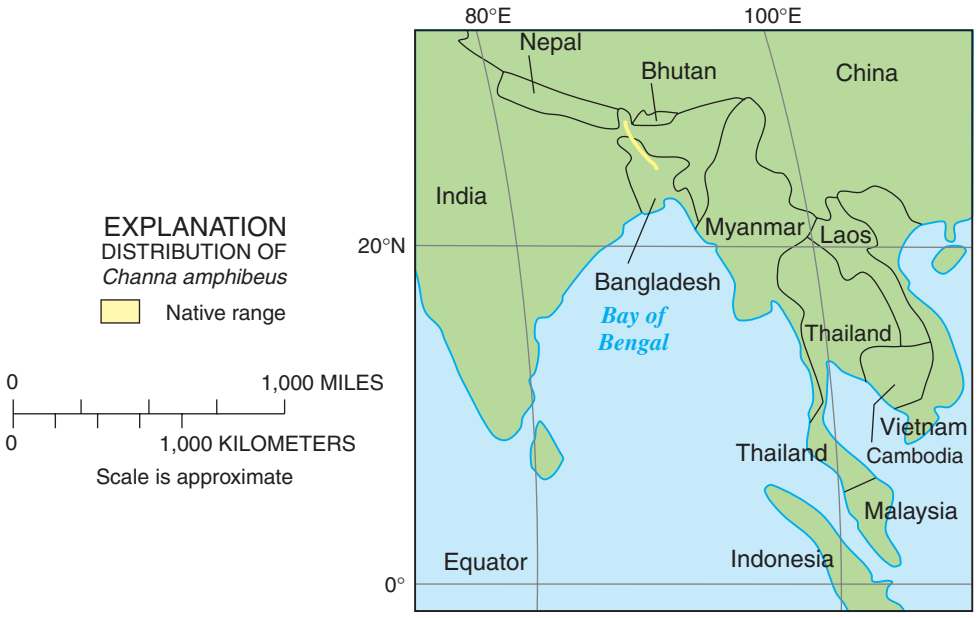
Characters: Gular part of head without patch of scales. Dorsal fin rays 50; anal fin rays 35; pectoral fin rays 15, pelvics 6; lateral line scales 81; cheek scales 9; scale rows above lateral line 5, below lateral line 13; predorsal scales 17; two large scales on underside of both sides of lower jaw. Head length 27.6 percent standard length; anal fin length less than 50 percent of pectoral fin length. Mouth large, maxilla extending far beyond posterior margin of eye. Many small conical teeth in premaxilla; three large conical teeth in prevomer; about four medium-sized canines on each

side of palatine; row of about five canine teeth on each dentary, smaller than those on palatine; many small conical teeth on outer part of dentary. Characters based on neotype (Musikasinthorn, 2000).

Commercial importance in the United States: Unlisted on aquarist-oriented websites. Negligible likelihood of being imported for sale in aquarium fish trade or live-food fish markets.

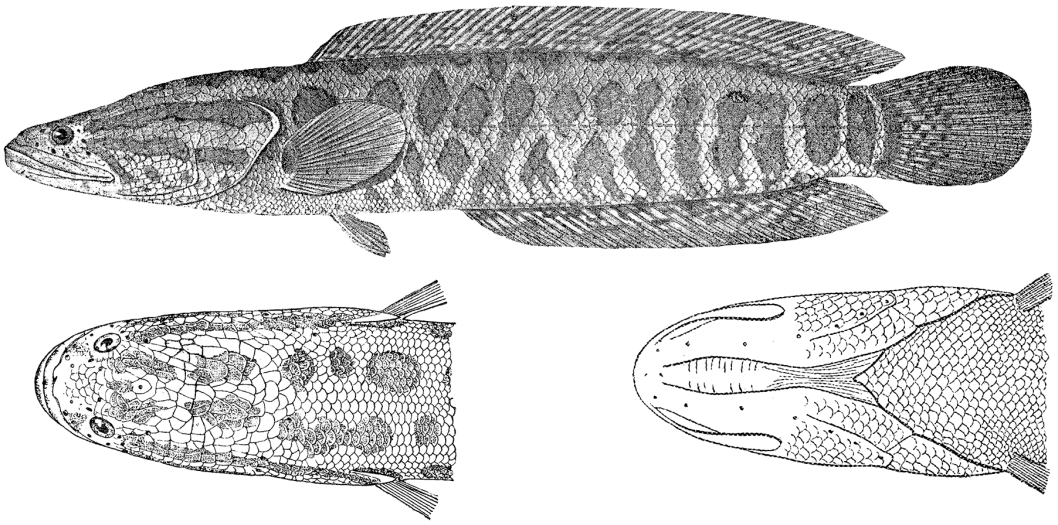
Commercial importance in native range: Unknown.

Environmental concerns: Unknown, but the species is probably a predator on other fishes and invertebrates.



Channa amphibeus

Channa argus (Cantor, 1842)
Northern Snakehead



After Berg, 1933

Original description: *Ophicephalus argus* Cantor, 1842:484. General features of Chusan, with remarks on the flora and fauna of that island. Ann. Mag. Nat. Hist. (n.s.), 9(60):481-493. Type locality: Zoushan Dao (Chusan Island), China. Syntypes: BMNH 1843.7.21.3; BMNH 1860.3.10.

Synonyms: *Ophicephalus pekinensis* Basilewsky, 1855:225, tab. 9, fig. 3.

Ophicephalus argus warpachowskii Berg, 1909:200.

Ophiocephalus argus kimurai Shih, 1936:81, fig. 5.

Common names: **northern snakehead**; Amur snakehead; eastern snakehead; ocellated snakehead; zmeegolov (Russian, Ussuri Basin and Lake Khanka region; Berg, 1965); her-yu (China; Evermann and Shaw, 1927); ga mul chi (Korea); kamuruchi, raigyo (Japan; Bailey and Haller, 1977; Uyeno and Arai, 1984; Hosoya, 2002).

Native range: Middle and lower Heilong (Amur) River basin; Songhua (Sungari) River, Manchuria; Tunguska River at Khabarovsk, Russia; Ussuri River basin; Lake Khanka (Herzenstein and Warpachowski, 1887; Berg, 1965; Popova, 2002); Korea, except northeastern region (Okada, 1960; Berg, 1965); rivers of China southward and southwestward to upper tributaries of the Chang Jiang (Yangtze) River basin in northeastern Yunnan Province (Evermann and Shaw, 1927; Kimura, 1934; Nichols, 1943; Mori, 1952; Berg, 1965; Xinluo and Yinrui, 1990; Ruihua, 1994). Reported from Guangdong Province, China (Pearl River Fisheries Research Institute, 1991), likely an introduction there. Widely distributed in Chinese reservoirs (Sifa and Senlin, 1995).

Introduced range: Occurrence of this species in the upper reaches of the Bei (Beijiang) River, Guangdong Province, China, is apparently the result of an introduction (Pearl River Fisheries Research Institute, 1991). Introduced from Korea in the early 1900s and established in many waters of central and southern Japan (Nakamura, 1963; Uyeno and Akai, 1984), considered as a "careless importation" (Okada, 1960). Chiba and others (1989) recorded the dates of these introductions as 1923-1924, noting that the species was reproducing in experimental or natural ponds and adding "Predation on native species" as a remark. In Japan, present and established in Hokkaido, Honshu, Kyushu, and Shikoku (Hiroshi Ueda, personal commun., 2001).

Holcík (1991) reported this species as introduced into "Czecho-Slovakia" and Russia, beginning in 1949. Holcík did not provide specific localities of introduction or information on status of the releases. Bogutskaya and Naseka (2002) listed *Channa argus* as having been transplanted within Russia. Nina Bogutskaya (personal commun., 2002) reported failed early introductions of the northern snakehead into the Volga Delta and ponds in Ekaterinburg (formerly Sverdlovsk) Province in the southern Urals. An experimental introduction was made in ponds of Moscow Province during 1949-1950 that established. In 1953, it was recommended that this

Juvenile northern snakehead, about 4 cm long, captured from pond in Crofton, Anne Arundel County, Maryland, July 9, 2002. Photo by Algerina Perna; reproduced with permission of the Baltimore Sun.

species should be stocked widely but that failed to happen. There was one report in a Russian aquarium journal in 1963 noting occurrence of this snakehead in small lakes in the Podolsk Region, Moscow Province, but the species is presently absent from the Moscow area. Tandon (1976) reported that acclimatization experiments were conducted in the former Soviet Union after 1950, and that fry were collected from ponds near Moscow and the Ukraine in 1955 and sent to Czechoslovakia for acclimatization purposes. He concluded that the source of the original stock was the Amur basin, not the Yangtze of China. In further support of the Amur basin having been the source of the stock, Zhadin and Gerd (1963) noted that "rearing of many Amur fishes possessed of frost resistance and great plasticity was recently initiated in water bodies in the European U.S.S.R." and included the northern snakehead among species imported.

Frank (1970) was more specific on introduction of northern snakehead to Czechoslovakia. He stated that the first shipment (three individuals) was made in December 1956 by V. Nikol'skiy of the Department of Ichthyology, Moscow University. These fish were introduced into a pond near Nižbor during Spring 1957 that later flooded into a nearby creek, resulting in the loss of the snakeheads. Nikol'skiy authorized a second shipment of 51 fish less than a year in age in December 1960. Several of these were released into three "natural ponds" near the Elbe River, with the remainder introduced to the same ponds during summer 1961. These ponds contained small cyprinids, roach (*Rutilus rutilus*) and white bream (*Blicca bjoerkna*), that served as prey for the snakeheads. In one pond that contained less vegetation, rudd (*Scardinius erythrophthalmus*) were used to supplement the food base. Snakeheads were periodically sampled from 1961-1964 to determine growth rates. Winters between 1961-1963 were unusually severe. All of the ponds became covered with ice during winter. The winter of 1963 was particularly cold over a long period of time (air temperatures often reaching -30 ºC and ice cover present for over 3 months). Due to decaying vegetation in two of the ponds producing hydrogen sulfide, a lack of oxygen, and thick ice on the surface, snakeheads and all other fishes perished in these ponds. Snakeheads did survive in the third pond, which was also being used experimentally to test if brown trout (*Salmo trutta*) could be used to control overpopulation of perch (*Perca fluviatilis*). During the winter 1963, the supply of roach and white bream was eliminated in the third pond by snakeheads and brown trout; the food base was supplemented with perch fry and snakeheads survived, but failed to grow. It was concluded that the northern snakehead could be acclimatized to Czechoslavakia as long as sufficient food existed. Interestingly, when the pond was cleared of vegetation for fish removal at the end of the experimental period, the northern snakeheads buried themselves in mud on the pond bottom making their capture difficult.

Borisova (1972), Amanov (1974), Dukravets and Machulin (1978), Usmanova (1982), Guseva (1990), and Dukravets (1992) documented introduction of *Channa argus* into the Aral Sea basin (about 45º N) in the early 1960s and its presence in the Amu Dar'ya, Syr Dar'ya, and Kashka-Dar'ya rivers of Kazakhstan, Uzbekistan, and Turkmenistan. The initial importation in 1961 of the northern snakehead was accidental when it was included with target phytophagous cyprinids (grass carp, *Ctenopharyngodon idella*, and silver carp, *Hypophthalmichthys molitrix*) that were destined for use in ponds adjacent to the Syr Dar'ya River. Introduction into the ponds occurred at "the 'Akkurgan' fish combine" (Amanov, 1974). Snakeheads escaped from ponds in 1964 and soon became established in the Syr Dar'ya (Amanov, 1974). Dukravets and Machulin (1978) reported that this snakehead migrated downstream into the Aral Sea about 1965. Similar escapes from ponds along the Kashka-Dar'ya in southern Uzbekistan in 1964 also led to establishment. It was also released with carp (*Cyprinus carpio*) in 1964 into Chimkurgan Reservoir in the Kashka-Dar'ya basin from a fish farm (Amanov, 1974; Usmanova, 1982; Baltz, 1991). Baltz (1991), however, cited 1963 as the year of introduction into the Aral Sea basin. At present,

the Aral Sea has almost disappeared and there are now hundreds of kilometers between the terminal reaches of these rivers and the former coastline of the Sea (Nina Bogutskaya, personal commun., 2002). Moreover, the salinity of the Aral Sea (10-12 ppm in about 1990; Baltz, 1991) is well above the tolerance limits of snakeheads.

All introductions into western Asia and eastern Europe were thought by some to have originated from China, perhaps from Amur basin stock of *Channa argus*. Sal'nikov (1998), in a comprehensive study of the inland waters of Turkmenistan, stated that the Aral Sea introduction source was the Yangtze basin of China. He reported the initial introductions of northern snakehead into Uzbekistan, with later migration through the Aral Sea into the Amu Dar'ya and other waters of Turkmenistan. Dukravets and Machulin (1978) and Usmanova (1982) noted that the characters of the introduced stock mostly agreed with those of northern snakehead from the Amur basin. Dukravets (1992) reported additional introductions of this fish beginning in 1976 from the lower part of the Sarysu River, north of the middle Syr Dar'ya, followed by further releases into reservoirs of the Talas and Chu Rivers, north and northeast of Tashkent, the capitol of Kazakhstan, during the middle 1980s. The species was thriving in irrigation reservoirs and isolated ponds on the Talas River, and more than 10 metric tons were commercially harvested from the reservoirs in 1989 (Dukravets, 1992). The latitude of this area of Kazakhstan parallels those of the Vermont/Quebec border, Minneapolis, Minnesota, and Salem, Oregon, in North America, indicating a possible northern range of distribution should this snakehead become established in U.S. waters.

As noted earlier, presence of this species in Guangdong Province, southern China (Pearl River Fisheries Research Institute, 1991), is likely the result of an introduction.

This species is recorded from open waters of the United States. A large snakehead was captured by electroshocking by California Fish and Game Department personnel in Spiritwood Lake, located in the San Bernardino Mountains, north of San Bernardino, California, on October 22, 1997. The lake receives water from the California Aqueduct and serves as a reservoir for Los Angeles. A photograph of the specimen was taken and the specimen was frozen but later discarded without being preserved. The photograph has not yet been located. We sent a digital photograph of an adult *Channa argus* to the biologist who reported the capture in 1997 and he responded that this appeared to be the same species (John Sunada, personal commun., 2002). It is unlikely that another species of snakehead could survive in this high-altitude reservoir.

Two specimens were captured from the St. Johns River below Lake Harney, Seminole and Volusia Counties, Florida. The first was collected February 11, 2000, and the second on March 4, 2000. There are unconfirmed reports of three additional specimens having been caught nearby (Franklin N. Snelson, Jr., personal commun., 2001). An attempt was made by USGS personnel to collect additional specimens at this site by electrofishing in 2001, but none were collected. Additional attempts to collect this species will be undertaken.

On May 14, 2002 a Maryland angler caught a 43-45 cm long snakehead in a 1.8-ha retention pond behind a shopping mall in Crofton, Anne Arundel County, Maryland. The angler took photographs of the unusual looking fish before releasing it back into the pond. A month later, the angler took one of the photos to the Maryland Department of Natural Resources (MDDNR) headquarters in Annapolis for identification, and one of the biologists thought it might be a snakehead. That same day, the photograph was emailed to the USGS in Gainesville, Florida, where we readily identified the fish as a northern snakehead and immediately notified MDDNR. In fact, we had just completed and submitted a document on the risk assessment and evaluation potential for establishment (among other biological factors) to the U.S. Fish and Wildlife Service on the entire family of snakeheads about a week prior to when the Crofton pond fish was initially caught.

A second snakehead (about 66 cm long) was caught by a second angler in the same retention pond on June 30, 2002. On the evenings of July 7-8, he dipnetted eight juvenile snakeheads from the pond, which we subsequently confirmed as northern snakeheads. This was the first proof that the species was established as a reproducing population. Later that week (July 11), MDDNR biologists captured an additional 99 juveniles ranging 5-6 cm in length, using backpack electrofishing units close to shore (Steve Early, personal commun., 2002). During the following week, more juveniles about the same size were captured by electrofishing. The pond and two adjacent smaller ponds were treated with herbicides by MDDNR personnel on August 18, 2002. Two dead juveniles, about 10 cm in length, were collected from the largest pond on August 20, 2002.

All three ponds were treated with rotenone on September 4. No snakeheads were found in the two smaller ponds. Dead fish ceased rising to the surface of the largest pond on September 7. The lengths of recovered northern snakeheads included two ranging from 69-70 cm, two 59 cm individuals, two ranging from 41-43 cm, more than 800 from 10-10.5 cm, and 566 young juveniles about 3.5 cm. The total number of snakeheads recovered was greater than the number of native fishes killed (Bob Lunsford, personal commun., 2002), although the biomass of natives was greater (Steve Early, personal commun., 2002).

A specimen of northern snakehead was captured by Massachusetts Department of Fish and Wildlife personnel in Newton Pond, Shrewsbury, Worcester County, Massachusetts, on October 4, 2001 (Karsten Hartel and Todd Richards, personal commun., 2001; Hartel and others, 2002). The likely source for both the Florida specimens and the one from Massachusetts is live-food fish markets.

In early August 2002, Gene Polk from Charlotte, North Carolina, reported that he and an angling partner caught two northern snakeheads from Lake Wylie, a reservoir on the Catawba River, near the U.S. Route 74 bridge. These fish were identified as *Channa argus* (Wayne Starnes, personal commun., 2002).

The USGS received an unconfirmed report of an angler who caught a snakehead near Rockport, southeastern Texas, that he believed was a northern snakehead based on illustrations in Howells and others (2002). He reportedly released the specimen without photographing it and has not followed up on his promise to provide a collection location or size of the fish (Robert Howells, personal commun. 2002).

Size: To 85 cm (Okada, 1960), although Nina Bogutskaya (personal commun., 2002) reported seeing captured specimens in Russia approaching 1.5 m total length. In the Amur River where the species is native and the Syr Dar'ya of Kazahkstan where it is introduced, males tend to be larger than females, with a higher dorsal fin, wider interorbital distance, and longer snout, postorbital distance, and upper jaw. Moreover, morphometrics vary with age (Dukravets and Machulin, 1978).

Habitat preference: Stagnant shallow ponds or swamps with mud substrate and aquatic vegetation; slow muddy streams (Okada, 1960). Also occurs in canals, reservoirs, lakes, and rivers (Dukravets and Machulin, 1978; Dukravets, 1992; Nina Bogutskaya, personal commun., 2002). This species is an obligate airbreather (Uchida, 1933). It appears to occupy waters, usually with vegetation, close to shore, and also feeds in schools (Nina Bogutskaya, personal commun., 2002).

Temperature range: 0 to >30 ºC (Okada, 1960).

Reproductive habits: Soin (1960) provided a detailed, illustrated report on spawning and development of the northern snakehead from within its native range. His study was based on observations made at a fish farm adjacent to the Songhua Jiang (Sungari River), northeastern China, in July 1958. He found fertilized eggs, about 1 day old, within an open nest (=cleared of vegetation) about 1 m in diameter and 60-80 cm deep. The eggs were guarded by two adults. Eggs were described as buoyant due to presence of a large lipid droplet that was more than three-quarters the diameter of the egg. Each egg had a diameter of 1.8-1.85 mm and the yolk was bright yellow. At 1 day of age, the length of an embryo removed from a fertilized egg was 3.2 mm. Hatching occurred 12 hours later at temperatures of 23-25 °C, about 2 days after spawning, and each larva was about 4.5 mm long. Respiration was through the caudal vein, the subintestinal vein that covers much of the yolk sac, and the enlarged ducts of Cuvier. Pectoral fins appeared about 1 day after hatching and larvae were about 5.7 mm long. Yolk was noticeably resorbed, ducts of Cuvier were reduced in size, and respiration was primarily through the subintestinal and hepatic veins that covered about two-thirds of the yolk sac surface. An oral aperture was present and an operculum covered the developing gills. A length of 7.1 mm was reached at 2 days following hatching and most of the yolk was resorbed. Nevertheless, the large lipid droplet was still present and caused what remained of the yolk sac to protrude laterally, producing a pair of cystiform structures. Melanophores had become well developed in the skin, giving the larvae a very dark color. By 3 days old, very little yolk remained, external blood vessels became markedly reduced, respiration by gills had begun, and the cystiform outpocketings remained visible on top of what remained of the yolk sac. Pectoral fins, used in locomotion, had enlarged, and the larvae, at 7.3 mm in length, had begun to feed. Larvae remained near the nest surface, grouped together, guarded by adults. About 2 weeks after hatching, larvae were approaching 11 mm in length, the yolk sac and cystiform processes had disappeared, fin rays were visible in the pectorals, coloration was black, and the epibranchial cavities that will later be used for aerial respiration had begun to develop. A length of 2 cm was reached by the fourth week after hatching, pelvic fins were developing, epibranchial

breathing cavities had become functional, and body color had changed from black to brown. Larvae of this size had lost their aggregative behavior and moved to slightly deeper water. Scales did not develop until the early juveniles had reached a length of 4-4.5 cm, when the mottled pattern of dark blotches characteristic of the species had appeared.

Many of the reports on this species vary considerably from what was observed following its introduction into Maryland. The northern snakehead has been said to reach sexual maturity in about 3 years at a length of 30-35 cm in the Amur and Syr Dar'ya, although some can spawn during the second year (Dukravets and Machulin, 1978). Okada (1960) reported spawning at 2 years at a length of 30 cm in Japan, and Nikol'skiy (1956) indicated the same for northern snakeheads in the Amur basin, differing from the age report given by Dukravets and Machulin (1978). This species builds a mostly circular nest of pieces of aquatic plants, about 1 m in diameter, in shallow aquatic vegetation. The water surface above the nest is cleaned by the parents, and spawning occurs at dawn or in early morning. The female rises near the surface and releases eggs, which are then fertilized by the male. Eggs are pelagic, nonadhesive, spherical, yellow, and about 2 mm in diameter. Eggs hatch in 28 hours at 31 ºC, 45 hours at 25 ºC, and 120 hours at 18 ºC. Number of eggs released ranges between 1,300-15,000, with an average of 7,300. Wee (1982) cited Frank (1970) who reported fecundity for this species of about 50,000 oöcytes. The report by Frank (1970) was based on examination of individuals in Czechoslovakia, imported from Moscow, Russia, and apparently of Amur basin stock. Additionally, fecundity in the Syr Dar'ya basin is higher than reported for the species in the Amur basin by Nikol'skiy (1956), about 22,000-51,000 in the Amur basin and a low of 28,600 to a high of 115,000 in reservoirs and lakes of the Syr Dar'ya basin (Dukravets and Machulin, 1978). Berg (1965) reported that the northern snakehead spawned five times per year in the Amur basin. Dukravets and Machulin (1978), however, noted that it spawns two to three times in the Syr Dar'ya basin, and in one group of lakes only once per year, typically from May to June at a water temperature of 18-20 ºC. Newly hatched larvae are about 4 mm in length and black. Larvae remain in the nest, guarded by one or both parents, until the yolk is resorbed and body length is about 8 mm. Larvae leave the nest as a group after yolk resorption and begin feeding on plankton. A post-larval stage follows until a length of about 18 mm is reached at which time aerial respiration begins. Young then begin feeding on small crustaceans and fish larvae. Parental care continues through the post-larval stage.

Feeding habits: Post-larvae feed on plankton, juveniles on small crustaceans and fish larvae, adults on fishes, frogs, crustaceans, and aquatic insects. This species is reported to be a voracious feeder (Okada, 1960). Dukravets and Machulin (1978) noted that in the Syr Dar'ya basin, northern snakeheads fed on 17 species of fishes, including young and fish up to 33 percent of the predator's body length. Larger prey included loach (*Cobitis*), bream (*Abramis*), carp (*Cyprinus carpio*), and perch (*Perca fluviatilis*). Other food items included crayfish, dragonfly larvae, beetles, and frogs, as well as plant material that was probably ingested incidentally with prey. Guseva (1990) summarized dietary changes in the Amu Dar'ya basin related to age based on Guseva and Zholdasova (1986). Northern snakeheads feed on "crustacean zooplankton, Cladocera," copepods, and small chironimid larvae for the first month of life. Once a length of 4 cm is reached, they begin to feed on fishes and when juveniles become 13-15 cm, fishes dominate 64-70 percent of the diet. Juveniles up to 30 cm feed almost exclusively on fishes (90 percent of diet), mostly small goldfish (*Carassius*) and roach (*Rutilis*). Moreover, in the Amu Dar'ya basin, northern snakehead feed only from late March to the end of October. Feeding begins when water temperature reaches 10 ºC with 45 percent of its annual food consumption completed by May. Roach dominated in the diet, but commercial species such as carp, zander (*Sander*), bream, grass carp (*Ctenopharyngodon idella*), and various catfishes were also consumed. Another 46 percent of annual food consumption occurred during June and July at temperatures of 20-27 ºC with carp, zander, grass carp, and bream dominating (50 percent of diet; Guseva, 1990). Feeding declined by autumn as water temperatures decreased to 12-18 ºC and ceased when temperatures dropped below 10 ºC.

This species is reported to feed in schools, with most activity at dusk into early night and again before dawn, typically in vegetation close to shore. It is also reported that actively feeding adults make grunting noises "like pigs" (Nina Bogutskaya, personal commun., 2002). Similarly, Soin (1960) noted clicking sounds produced by the northern snakehead in ponds adjacent to the Songhua Jiang (Sungari River), northeastern China, as the fish rose to the surface to breathe air.

Characters: Gular part of head without patch of scales. Head somewhat depressed anteriorly; interorbital area flat; eye above middle of upper jaw. Mouth

large, reaching far beyond eye. Villiform teeth present in bands with some large canine-like teeth on lower jaw and palatines. Lateral line scales 60-67; 8 scale rows above lateral line to dorsal fin origin; 12-13 scale rows below lateral line to anal fin origin. Dorsal fin elongated, with 49-50 rays; anal fin with 31-32 rays. Origin of pelvic fin beneath 4th dorsal fin ray. Pectorals extending beyond base of pelvic fins.

The body has a very distinctive color pattern. Background color is golden tan to pale brown with a series of dark blotches on the sides and saddle-like blotches across the back interrupted by the dorsal fin. The species is capable of darkening its background colors to the point of almost obscuring the blotches (personal observation). The upper blotches on the sides are typically separate anteriorly, but more posterior blotches may coalesce with ventral blotches. There is a dark stripe from just behind the eye to the upper edge of the operculum with another dark stripe below from behind the orbit extending to the lower quadrant of the operculum. Coloration of juveniles is virtually the same as in adults, a characteristic atypical for many snakehead species.

Coloration of the northern snakehead is quite similar to that of the blotched snakehead, *Channa maculata*. A key character for separating these two is the bar-like markings on the caudal peduncle. In *C. maculata*, the most posterior dark bar (usually complete) is preceded and followed by pale bar-like areas, whereas in *C. argus*, such pale markings are absent and the final dark marking is irregular, often blotch-like.

Commercial importance in the United States: Generally not listed on aquarist-oriented websites. Nevertheless, this species has been imported for sale in live-food fish markets and has been the most widely available snakehead in the U.S. It likely has comprised the largest volume and greatest weight of live snakeheads imported into the U.S. until 2001. The authors obtained specimens that were procured alive from fish markets in New York, Houston, Pembroke Pines, and Orlando, as well as photographs of live northern snakehead in markets in New York and St. Louis that were taken by Leo Nico of the USGS. Photographs from the St. Louis market were taken in mid-July 2002, after northern snakeheads were found established in Maryland; the storeowner had the fish marked as "mudfish." Also, see below under **Environmental concerns**.

A fish farmer in Arkansas was discovered culturing northern snakeheads in 2001 when possession of live snakeheads was legal. This was verified in July 2002 when it was also learned that two additional Arkansas aquaculturists were then culturing northern snakehead. The report included information that the original snakehead aquaculturist had been approached by a live-food fish importer in New York and asked if he could culture snakeheads for sale in U.S. markets. Apparently, the second two fish farmers decided that they too might profit from snakehead culture. Thus, as of July 2002, there were three domestic sources of cultured northern snakehead, although the importation, culture, and possession of snakeheads in Arkansas were prohibited on July 29, 2002.

Commercial importance in native or introduced range: This species is cultured in ponds, rice paddies, and reservoirs in China (Atkinson, 1977; Sifa and Senlin, 1995) and considered a valuable commercial fish in Korea (Berg, 1965). FAO (1994) listed a production of 500 metric tons in Korea in 1992. It is the most important snakehead cultured in China, with most culture activities centered in the Chang Jiang (Yangtze) basin (Fang Fang, personal commun., 2002). It never became a popular food fish following introduction into Japanese waters (Okada, 1960). In tributaries of the Aral Sea, Kazakhstan, large populations of this species are fished commercially with an annual catch reported of 1-5 metric tons (Baltz, 1991). Dukravets (1992), however, reported an annual catch of 10 metric tons from reservoirs on the Talas River, Kazakhstan.

Environmental concerns: This species is described as a voracious predator on other fishes, and also feeds on freshwater crustaceans. Moreover, its native range (24-53º N) and temperature tolerance (0-30 ºC) indicates a species that, if introduced, could establish feral populations throughout most of the contiguous United States and possibly some waters in adjoining Canadian provinces. Because it was found to be established in Maryland in 2002, perhaps also in Florida, and was the most widely available snakehead sold as a live-food fish in the U.S., the likelihood of its becoming more widely established is real.

Fourteen states banned possession of live snakeheads prior to August 2002. Among those states is Texas where possession of live snakeheads has been illegal for almost four decades (Howells and others, 2002). During Summer 2001, game wardens from the Texas Parks and Wildlife Department discovered large numbers of *Channa argus* being sold in live-food fish markets in Houston. Raids resulted in seizure of the fish and shipping documentation that traced the fish to a distributor

who had obtained the fish from a source in New York (Robert H. Howells, personal commun., 2001). The distributor was an aquaculture facility that had imported northern snakeheads for sale to retailers in Texas, and agents confiscated the fish (Howells and others, 2002).

Florida also prohibits possession of live snakeheads. Following the discovery of the bullseye snakehead, *Channa marulius*, that was established in Tamarac, Broward County, Florida, in spring 2001, agents of the FFWCC raided two live-food fish markets, one in Miami, Miami-Dade County, and another in Pembroke Pines, Broward County. They confiscated several live *C. argus* (Florida Fish and Wildlife Conservation Commission, 2001). *Channa argus* was also confiscated from a live-food fish market in Orlando, Orange County, by FFWCC agents in July 2002.

Despite Florida's prohibition, one of the authors (JDW) purchased a live northern snakehead from a fish market in Orlando, Orange County, in March 2002. The tank in which the fish was found was labeled "Chinese catfish," although the proprietor explained to the buyer that the fish was not a catfish but "a very special fish." The Center for Aquatic Resources Studies of the USGS Florida Integrated Science Center has a permit to possess certain restricted fishes including snakeheads. This purchase was made to prove that illegal fish can be purchased in Florida. FFWCC agents confiscated four live northern snakeheads from this market on July 16, 2002.

The FFWCC licenses pet dealers, importers of restricted and tropical fishes, and retailers and wholesalers of non-native aquatic species. This last item includes markets that sell live-food fishes (Kyle Hill, personal commun., 2002). The Division of Aquaculture of the Florida Department of Agriculture and Consumer Affairs certifies and inspects fish culture facilities, and deals with permits for restricted species to fish farmers (Paul Zajicek, personal commun., 2002) but does not license retailers or wholesalers that sell live-food fishes. Restricted fishes can only be sold to people who possess a valid Aquaculture Certificate from Department of Agriculture and Consumer Affairs. Moreover, a retailer of live-food fishes who does not apply for a license becomes an illegal "unknown" to regulatory agencies. The markets in Miami, Pembroke Pines, and Orlando that were selling northern snakeheads did not have licenses to possess or sell live freshwater fishes (Kyle Hill and Barry Cook, personal commun., 2002). Clearly, there have been sources other than aquarium fish dealers from which live snakeheads could be purchased, raising the probability of introductions that could become established, as occurred in Crofton, Maryland, with *Channa argus*.

Snakeheads are also prohibited in Washington. At 11:35 a.m. on April 30, 2001, a driver for a Canadian fish wholesaler declared a shipment of live ling cod in Blaine, Washington. The shipment was bound for a seafood distributor in Seattle. Wildlife Inspector Michael Williams, U.S. Fish and Wildlife Service, inspected the shipment to find three open boxes containing fish he thought were "unusual looking." When he asked the driver what they were, his reply was that they were snakeheads that had been pond raised in China and shipped without water to Canada, adding this was the first time his employer had made such a shipment. Upon examining one box, Williams noticed the fish moved and, on further investigation, found that most were alive and some "capable of vigorous movement." Williams informed the driver that possession of live snakeheads was in violation of Washington State regulations. The driver was asked to kill the fish and began striking them with a board. Williams notified the Washington Department of Fish and Wildlife and, after returning to the truck, found that the fish were still alive despite the driver's attempt to kill them. He seized the 80 fish at noon and placed them in a freezer. Washington Department of Fish and Wildlife authorities arrived about 12:30 and removed the fish from the freezer. Most were still alive. State authorities took possession of the fish to proceed with penalties against the companies involved (Mike Williams, personal commun., 2003). The shipping invoice listed the fish as "Fresh Snakehead Fish–Product of China." The fish were subsequently identified as northern snakeheads (Ted Pietsch, personal commun., 2001).

Discovery of an established population of northern snakeheads in Maryland, catches by anglers of two verified and three unconfirmed specimens from the St. Johns River in east-central Florida, and others from a California reservoir, a pond in central Massachusetts, and two from a reservoir in North Carolina, coupled with proof of their availability in live-food fish markets at or near a size when they are reproductively mature, were reasons for substantial environmental concern.

Despite the fact that snakeheads are now prohibited from importation, several live specimens of northern snakehead were confiscated in California in July 2003.

Comments: The diploid chromosome number of *Channa argus* is 48 (Lee and Lee, 1986; Wu and others, 1986).

Distribution of *Channa argus* in the Eastern Hemisphere

Channa asiatica (Linnaeus, 1758)
Chinese Snakehead

UF 127103, 135 mm standard length. Specimen purchased in an Asian market in Kansas, October 2002. Photo by Buck Albert, USGS, Gainesville, Florida.

Original description: *Gymnotus asiaticus* Linnaeus, 1758:246. Systema Naturae, ed. 10. Holmiae, 1:i-ii + 1-824. Type locality: Asia. Holotype: ZIU 171.

Synonyms: (?)*Ophicephalus miliaris* Cuvier, 1831:439.

Channa ocellata Peters, 1864:392.

Channa fasciata Steindachner, 1866:480.

Channa sinensis Sauvage, 1880:58.

Channa orientalis Karoli, 1882:147.

Channa formosana Wu, 1929:73; Myers and Shapovalov, 1932:36.

Cuvier (1831) described *Ophicephalus miliaris* based on a description by Jean-Jacques Dussumier of a snakehead from Canton (Guangzhou), China. Dussumier's descriptions were made from live or fresh specimens and were considered quite accurate by Cuvier (Bauchot and others, 1990). Figure 10 in Bauchot and others (1990), an illustration of a snakehead lacking pelvic fins and based on Dussumier's description, appears to be *Channa asiatica*. Therefore, we have treated *O. miliaris* as a possible synonym of *C. asiatica*. Nevertheless, Peter Ng (personal commun., 2003) noted that a closely related species, *C. nox*, that has very similar markings to *C. asiatica*, is available for sale in live-food fish markets in Ghangzhou, raising the possibility that *O. miliaris* might be a synonym of that species. Resolution of this situation is complicated because there are apparently no types of *O. miliaris.*

Common names: **Chinese snakehead**; chi hsing yü (Yangtze River basin, China); hua-t'sai-yü (Tungting Lake on Chang Jiang [Yangtze] River); kôtal (Japan; Uyeno and Akai, 1984; Hosoya, 2002).

Native range: China, middle and lower Chang Jiang (Yangtze) basin, and Xun River basin in Guangxi and Guangdong provinces (Kimura, 1934; Pearl River Fisheries Research Institute, 1991). Also reported from Hainan Island, China (Kimura, 1934) where it is likely native rather than introduced.

Introduced range: Taiwan (Musikasinthorn, 2000); Japan, Ishigaki Shima Island in the Ryukyu Islands (Uyeno and Akai, 1984; Hosoya, 2002). Klee (1963) reported that this species was "occasionally found in Florida waters," but we have found no evidence that it is established.

Size: Up to 34 cm (Daiqin and others, 1999). By studying annual ring development on scales, they noted a linear relationship between scale length and body length for this species. They also commented that growth is rapid during the first 2 years of life and slows thereafter. They recommended regulating a minimal harvestable age of this species at 2.6 years for resource conservation purposes.

Habitat preference: No information available. Probably a riverine species.

Temperature range: No information available. Nevertheless, distribution within native range (32-22º N) indicates a warm temperate to subtropical species.

Reproductive habits: No information found concerning reproduction in natural habitats. Hosoya (2002) stated this species does not build a nest but provides parental care in Japan where the species was introduced. Breder and Rosen (1966) summarized this

species, in aquaria, as producing floating eggs, the eggs about the "size as that of the head of a pin." Reproductively active females become paler with a pink cast, with dark brown markings becoming darker and silver markings becoming brighter. Reproductively active males also become darker. The prespawning female rises to the surface of an aquarium, gulps air, and rolls from side to side. The male then rises, circles the female, and they embrace, rising to the surface with the male squeezing the female. They are reported to have rolled once, then sank, releasing themselves, repeating the sequence after a few minutes. In aquaria, spawning can occur every 6 to 10 days. Reproductive activities appear to occur at night. Hatching in aquaria occurs in about 24 hours at 28 ºC. There are some indications that the male may be a mouthbrooder. Both male and female are reported to aggressively protect against anything introduced into an aquarium when eggs or fry are present.

Feeding habits: No information found, but likely a thrust predator.

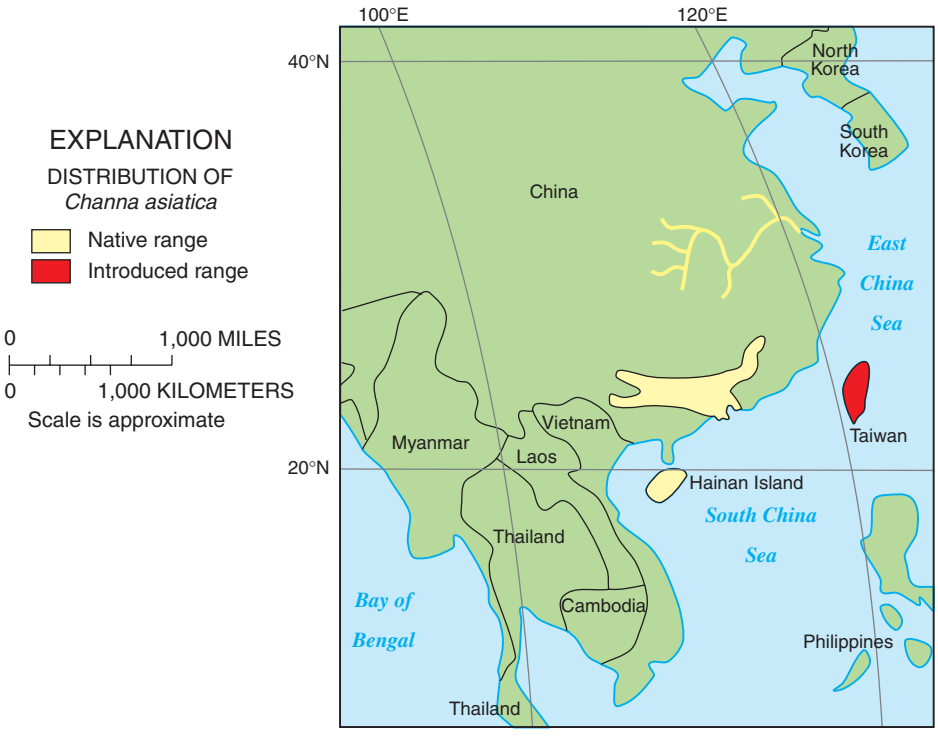
Characters: Gular region of head without patch of scales. Pelvic fins absent. Dorsal fin with 44 rays; anal fin 26 rays; pectoral fin 14 rays. Lateral line scales 57; predorsal scales 12; rows of scales between dorsal origin and lateral line 5; scale rows between lateral line and midline of belly 16. Color pattern distinct among snakeheads with dark chevrons on sides and large ocellus centered on caudal peduncle. The center of the ocellus is not round but more quadrangular in shape (Bureau of Aquatic Products Industry, 1988; Lee and Ng, 1991), unlike that illustrated in Pearl River Fisheries Research Institute (1991). The most closely related snakehead is *Channa nox*, which has 47-51 dorsal fin rays, 31-33 anal fin rays, and is black on the upper half of the body. Like *C. asiatica*, *C. nox* also lacks pelvic fins and has a large black ocellus on the caudal peduncle.

Commercial importance in the United States: Ross B. Socolof (personal commun., 2003) reported *Channa asiatica* as the first snakehead to have been imported to the contiguous United States for the aquarium fish trade. Subsequent accounts of this species in the aquarium fish literature (Innes, 1920, 1955; Armstrong, 1923; Stoye, 1935; Axelrod and Schultz, 1955) are indicative of its availability through much of the early to mid-1900s. Typically not listed on aquarist-oriented websites.

Commercial importance in native range: Nichols (1943) commented that it was never seen for sale in China. Nevertheless, it is sold in the aquarium fish trade outside its native range in Singapore (Ng and Lim, 1990). Daiqin and others (1999) recommended restricting the legal harvestable age to 2.6 years, a clear indication that the species is being fished commercially in China. Ping Zhuang (personal commun., 2002) noted that this species is now common in aquaculture in China.

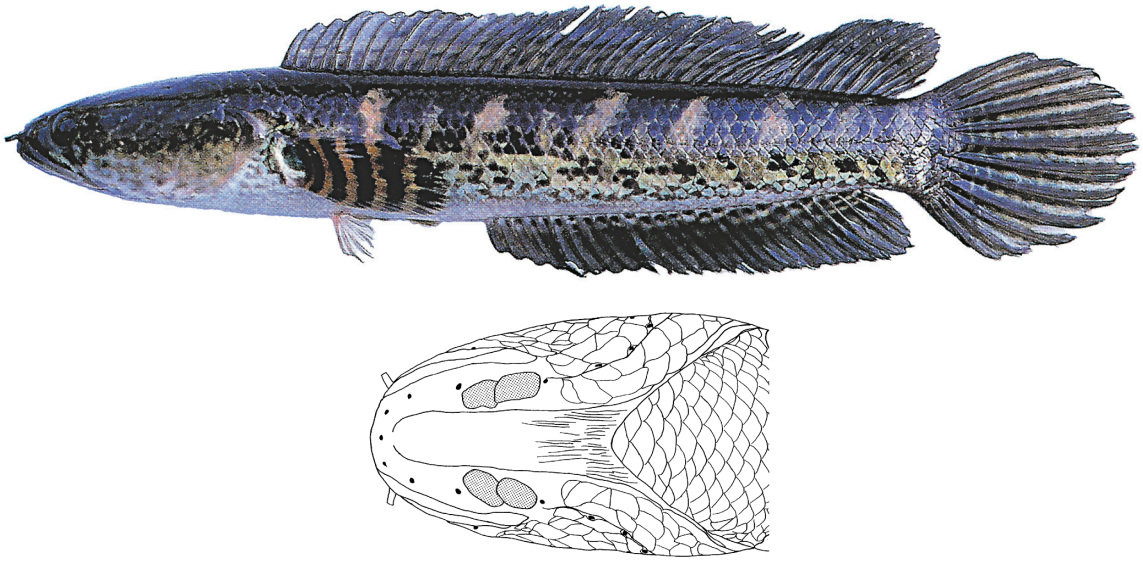
Environmental concerns: Probably a thrust predator on other fishes and invertebrates like many other snakeheads. According to Ross B. Socolof (personal commun., 2003), this was the first snakehead imported into the U.S. for the aquarium fish trade, the earliest imports occurring in the late 1800s or early 1900s.

Comments: The diploid number of chromosomes of *Channa asiatica* is 46 (Wu and others, 1986).



Channa asiatica

Channa aurantimaculata Musikasinthorn, 2000
Orangespotted Snakehead



Upper image: holotype, KUMF 3135, 190.8 mm standard length. **Lower image:** ventral view of head showing enlarged scales on lower jaw, paratype, KUMF 3136, 163.7 mm standard length. Reprinted with permission from Prachya Musikasinthorn, author, and Tomoki Sunobe, Secretary of the Ichthyological Society of Japan, from: Musikasinthorn, Prachya. 2000. *Channa aurantimaculata*, a new channid fish from Assam (Brahmaputra River basin), India, with designation of a neotype for *C. amphibeus* (McClelland, 1845). Ichthyol. Res. 47(1):27-32.

Original description: *Channa aurantimaculata* Musikasinthorn, 2000:27-32. *Channa aurantimaculata*, a new channid fish from Assam (Brahmaputra River Basin, India), with designation of a neotype for *C. amphibeus* (McClelland, 1845). Ichthyological Research, 47(1):27-37, figs. 1-5. Type locality: Dibrugarh town, Digrugarh, Assam, India. Holotype: KUMF 3135. Paratypes: KUMF 3136; NSMT-P 55735; ZSI uncataloged, collected with KUMF 3136.

Synonyms: No synonyms.

Common names: **orangespotted snakehead**; naga-cheng (Assam, India).

Native range: Endemic to middle Brahmaputra River basin, northern Assam, India (Musikasinthorn, 2000).

Introduced range: No introductions known.

Size: To about 40 cm.

Habitat preference: Forest streams, ponds, and swamps adjacent to the Brahmaputra River in subtropical rainforest conditions (Musikasinthorn, 2000).

Temperature range: Unknown, except preferred habitat and known range is subtropical.

Reproductive habits: No specific information, but probably a nest builder with pelagic eggs like the majority of channid fishes.

Feeding habits: No information, but more than likely a carnivorous predator as adults.

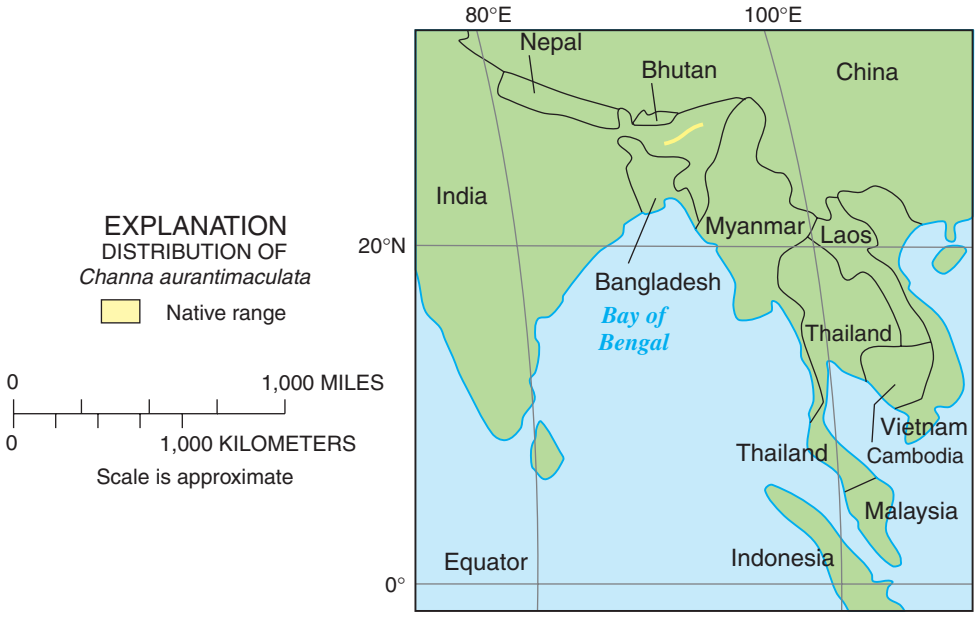
Characters: Patch of scales on gular part of head absent. Head elongated, mouth large, interorbital region almost flat. Dorsal fin rays 45-47; anal rays 28-30; lateral line scales 51-54; cheek scales 8-12; predorsal scales 13-15; total vertebrae 50-52; two large scales on each side of undersurface of lower jaw; pelvic fin

length less than 50 percent of pectoral fin length; cephalic sensory pores single without satellite openings. Small conical teeth in premaxilla with an additional series of somewhat larger conical teeth anteromedially; small teeth and 3 large conical teeth on prevomer; a row of conical teeth with 5 or 7 large canines on each side of palatine; dentary with medium-sized conical teeth on each side, also with 5 to 6 large canine-like teeth (Musikasinthorn, 2000).

Commercial importance in the United States: None known. Recently described species, not listed on aquarist-oriented websites and unknown for sale in live-food fish markets.

Commercial importance in native range: No specific information, but reported in markets in Assam, India (Musikasinthorn, 2000).

Environmental concerns: Unknown, but probably a predator on other fishes and invertebrates.



Channa aurantimaculata